Space Weather Technical Forecast

Issued on Tuesday, 14 December 2021 at 00:22 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of G1/Minor Geomagnetic Storms days 1-2 (14/15th)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was Very Low, although a number of B-class flares were observed. These primarily from an unnumbered sunspot containing active region Cri/Beta near the southeast limb (S21E61). Two other small sunspot regions are on the disc, also in the southeast hemisphere. AR2905 Cro/Beta has remained inactive and showing signs of decay, whilst a further unnumbered Cri/Beta region emerged in the last 12 hours near S29E37 and continues to gradually develop. No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR and ACE at L1, was at background levels 300-330 km/s, whilst its density was mainly above average at 15-20 ppcc. The Interplanetary Magnetic Field strength (IMF), Bt, was mainly weak with brief maximums at moderate, peaking 10nT at around 13/0415 UTC. The Bz component ranged from -7 nT to +7 nT but predominately northward (positive) since 13/0900 UTC. Phi angle has shown rotations between positive and negative values, but has been predominately negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels with the associated 24-hour integrated fluence below the Active threshold. Fluence of 2.88e6 was observed at 14/0000 UTC

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is expected to be Low to Very Low with a chance of C-class flares.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Solar winds are likely to soon become slightly elevated due to the late arrival of the fast wind of CH34. A further enhancement to elevated levels is then anticipated either later day 1 or day 2 (14th or 15th) from the fast wind of CH32, only gradually easing later day 3 (16th) onward. Geomagnetic Activity is forecast to be Quiet, potentially increasing to Unsettled with Active intervals early day 1 (14th) for a time. A more notable increase to Unsettled to Active with a slight chance of G1/Minor Storms then follows either late day 1 (14th) or during day 2 (15th). Activity then decrease to Quiet to Unsettled by day 3 (16th), and through day 4 (17th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels. The high energy electron flux (greater than 2 MeV) is expected to be Background to Moderate levels initially. The arrival of the fast winds of CH34, day 1 (13th), and then CH32 late day 1 (14th) or day 2 (15th), has the potential to increase the flux with persistently High flux possible by day 3 and 4 (16th and 17th), although confidence remains Low for this. The associated 24 hour fluence is expected to persist below the Active level day 1 and day 2, but with an increasing chance of rising above by the end of day 3 and day 4 (16th and 17th).

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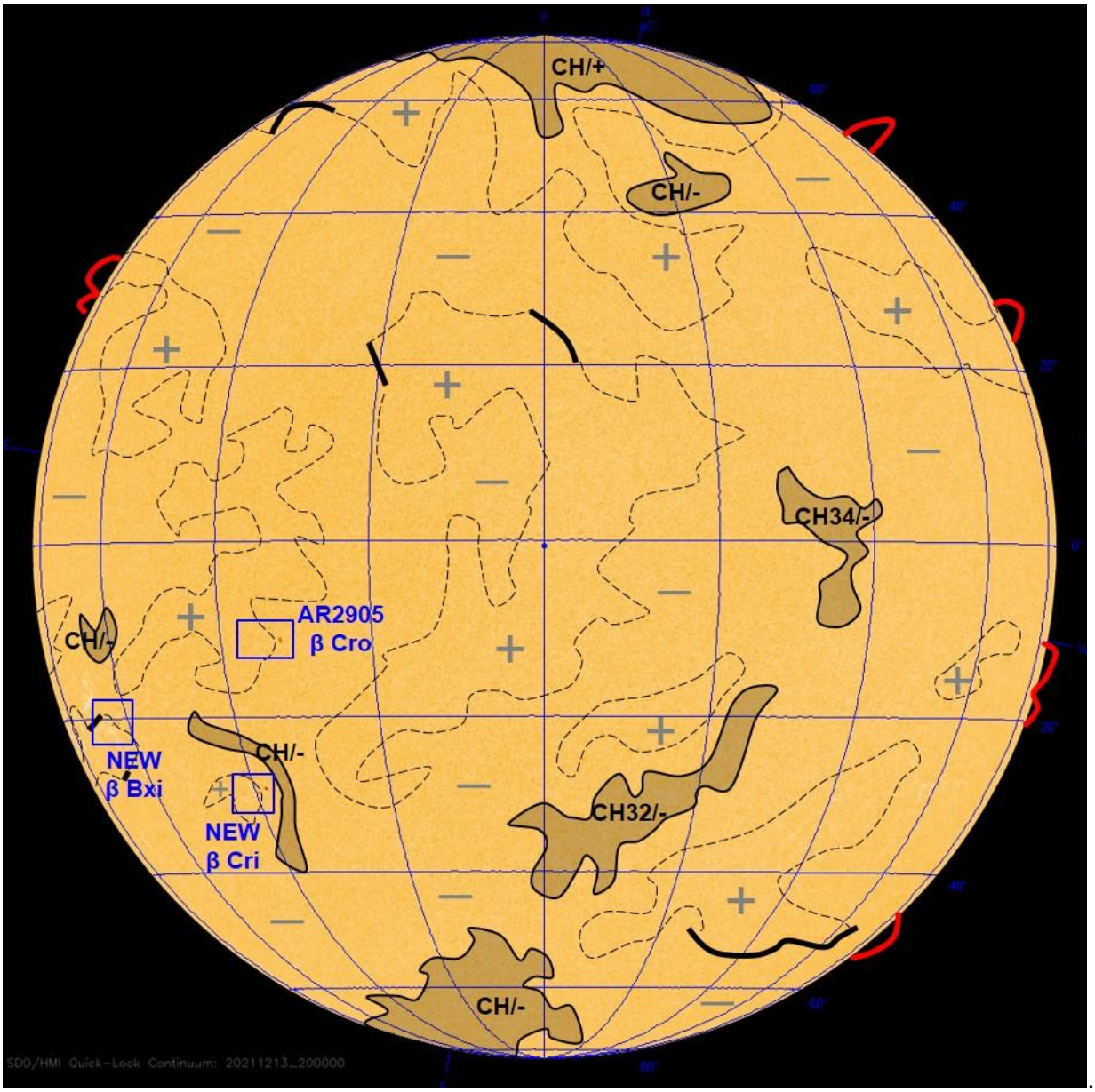
Figure 1. Solar Analysis Valid 13/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs. Connection to coronal hole 34 has been slower to occur than previously anticipated, but still expected in the coming hours, with solar winds likely becoming slightly enhanced day 1 (14th). A transition into the fast wind of coronal hole 32 is then expected either later day 1 or during day 2 (15th), although confidence is only moderate on the timings. Elevated winds of around 550 km/s are then expected before gradually easing later day 3 (16th) onward.

This is supported by enlil, which has an enhancement day 2 (15th), although this doesn't have any notable increase to speeds from CH34. Persistence from the previous rotation is currently not helpful, as this would suggest we would already be connected to this fast wind, however the coronal hole has since retreated eastward, as evident on a comparison of SDO aia-193 imagery.

Geomagnetic Activity is forecast to be Quiet at first, but potentially increasing to Unsettled with Active intervals day 1 for a time. A more notable increase to Unsettled to Active with a slight chance of G1/Minor Storms then follows either late day 1 (14th) or during day 2 (15th). Activity then decrease to Quiet to Unsettled by day 3 (16th), and through day 4 (17th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: Solar Wind Persistence Model

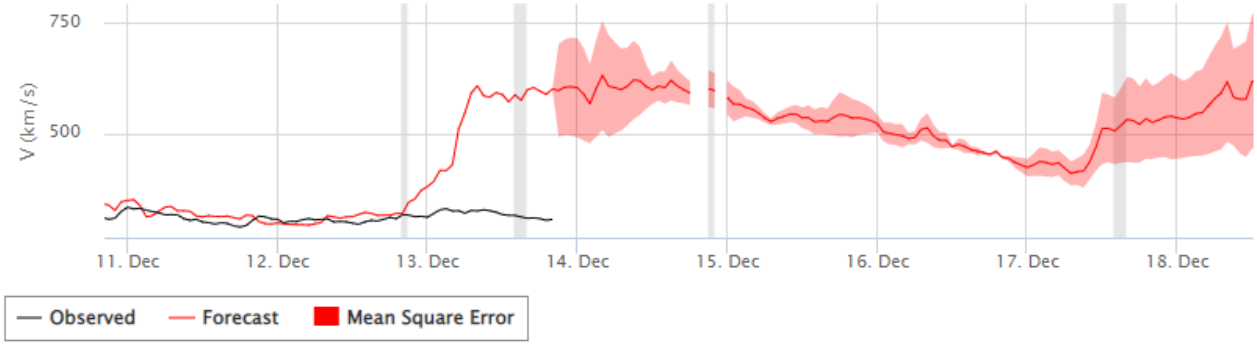

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Figure 3: SDO aia-193 of previous rotation (left) and current rotation (right)

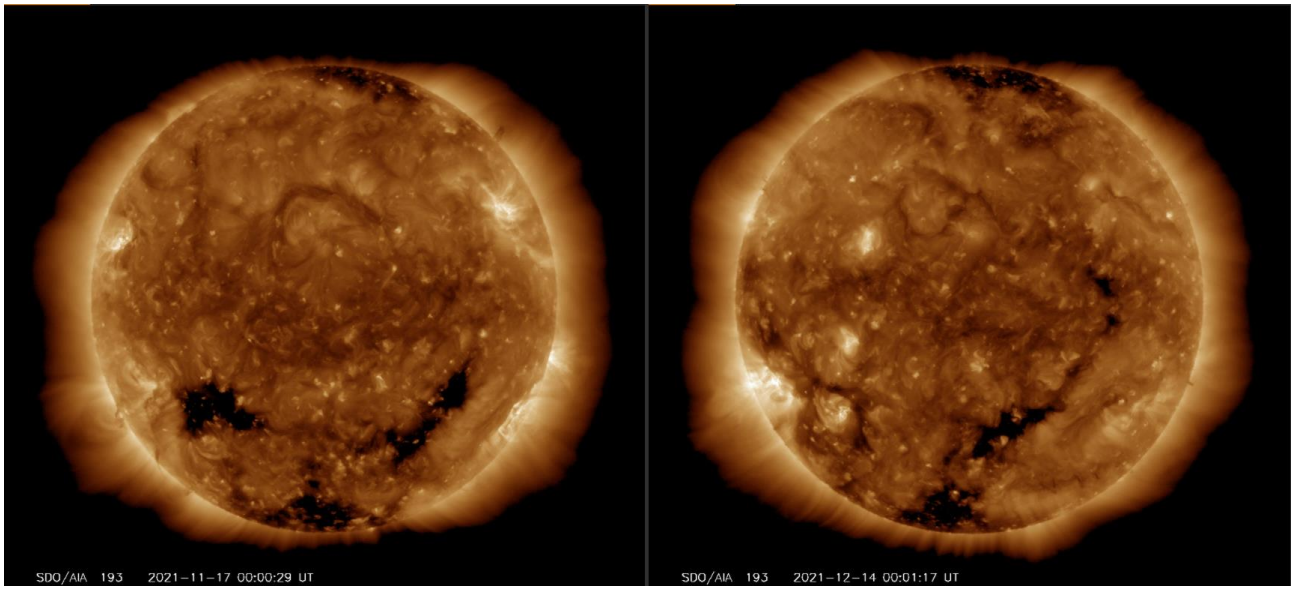
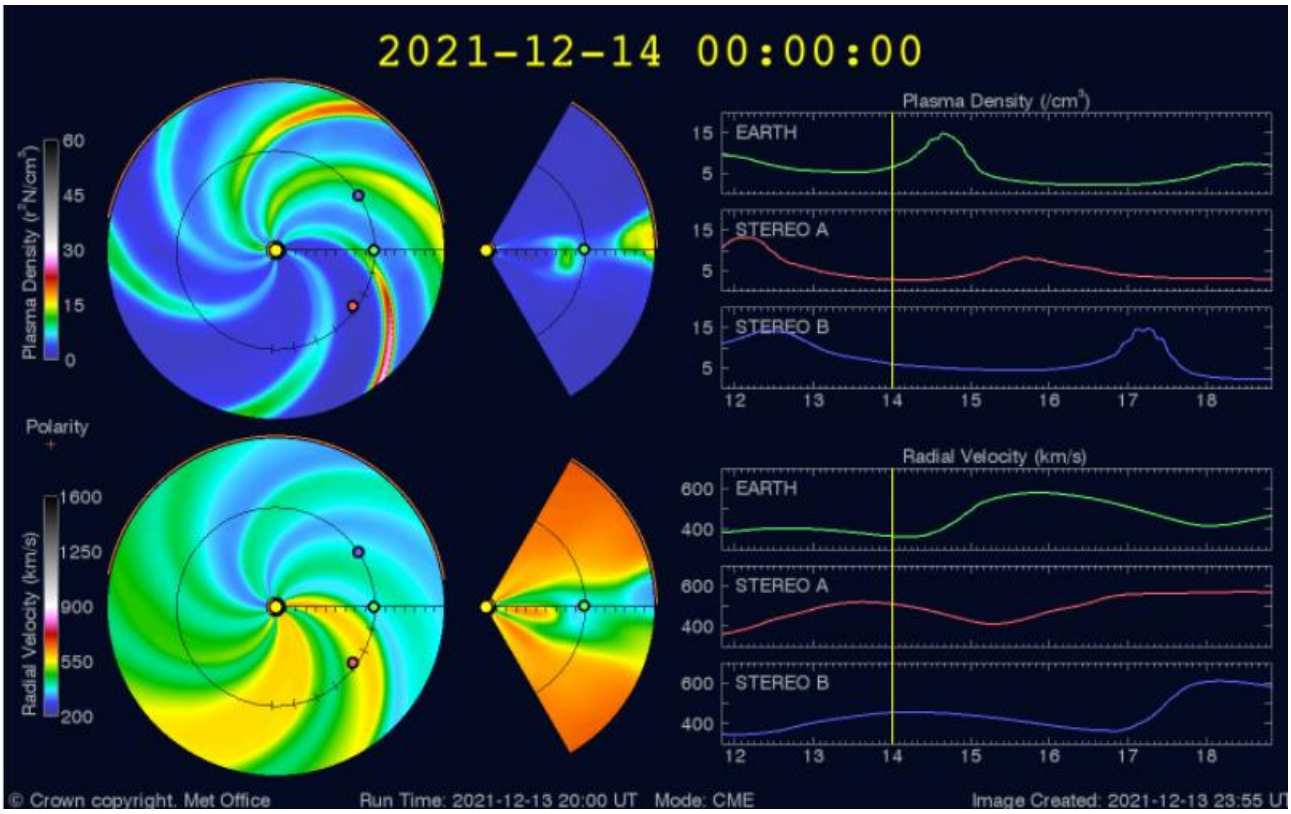


Figure 4: MOSWOC Enlil showing likely enhancement late 14th and 15th.



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Radio Blackouts - X-Ray Flares:

Solar Activity was Very Low in the last 24 hours, although a number of small B-flares were observed from the three sunspot containing active regions on the Earth-facing disc, all in the southeast quadrant.

AR2905 is currently the only numbered region, but remains a small a simple Cro/Beta spot. Two other developing regions have also been emerging in the last 24 hours. The most active of these is a Cri/Beta region amongst an area of plage around S21E61 at time of issue, however a further Cri/Beta region has also developed near S29E37 and shown some fairly rapid development in the last 12 hours. These regions will need watching for any further development.

With the potential for C-flares from these regions, solar activity is forecast to be Very Low to Low. Whilst there is a slightly above background chance of stronger flares from these regions, this is dependent upon further growth from any of these regions.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	2	2	2	2
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 5: GOES-16/17 X-ray flux

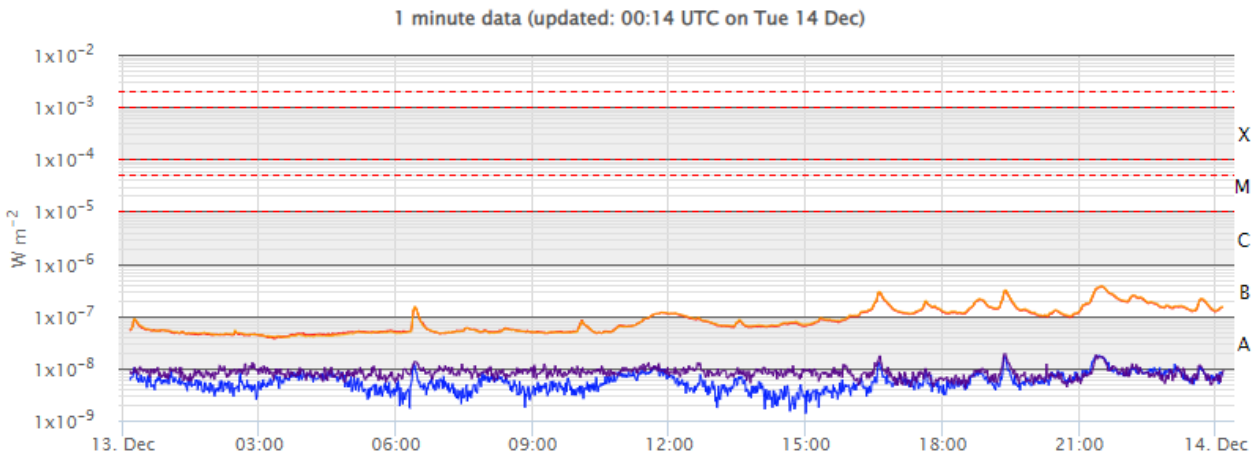

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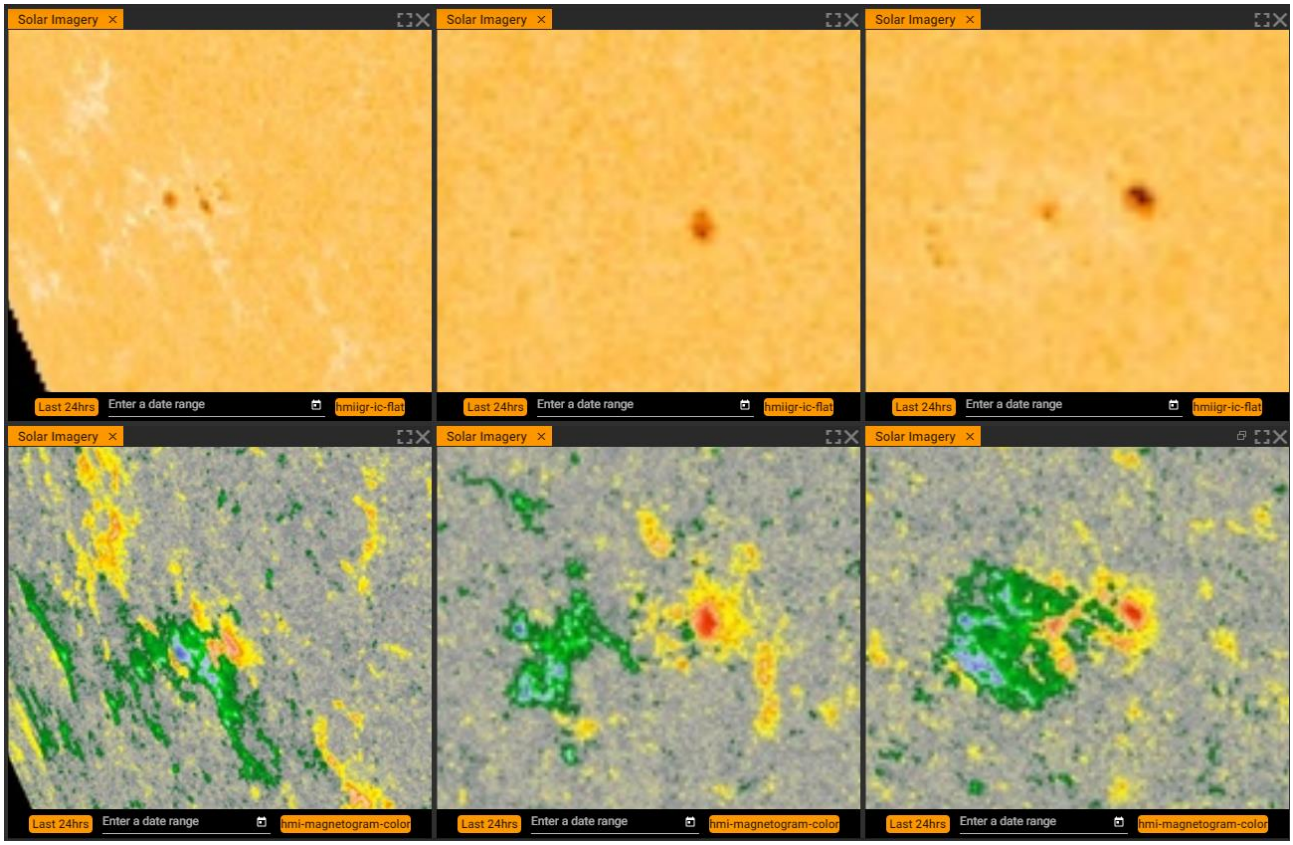
Figure 6: Zoomed images on SDO Hmi-Intensitygram and Hmi-Magnetogram of the three sunspot regions currently on disc.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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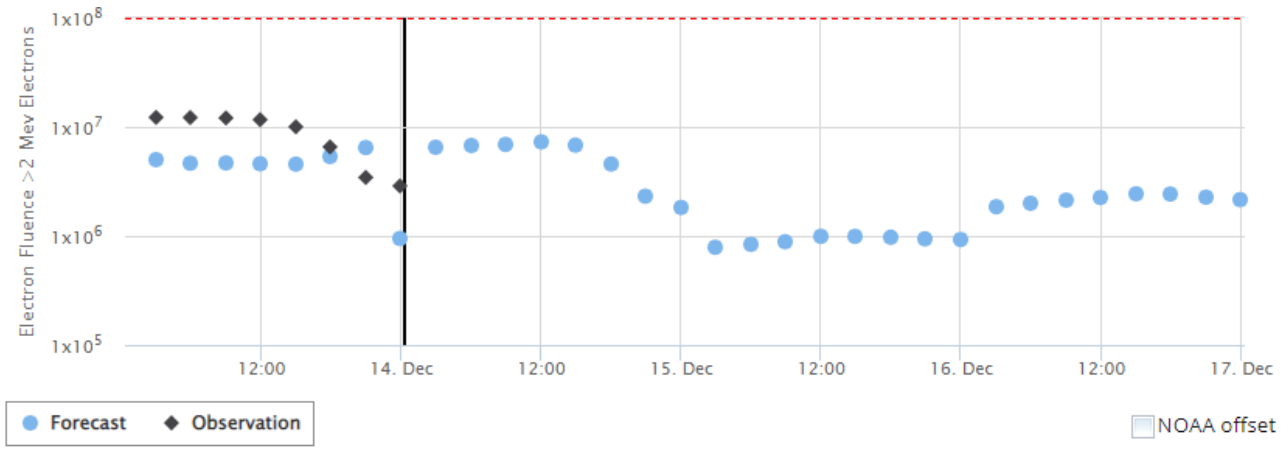
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be Background to Moderate levels initially. The arrival of the fast winds of CH34, and then CH32, through day 1 and 2 (14th and 15th), has the potential to increase the flux with persistently High flux possible by late day 3 or day 4 (15th or 16th), although confidence remains Low for this.

The associated 24 hour fluence is expected to persist below the Active level day 1 and day 2, but with an increasing chance of rising above by the end of day 4. This is supported by REFM which maintains fluence below the Active threshold.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 7: Observed>2 MeV Fluence with REFM



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